

APPENDIX C. COMPUTING POLLUTANT LOAD EXPORT

SIMPLE METHOD FOR CALCULATING PHOSPHORUS EXPORT

The Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. The method was developed to provide an easy yet reasonably accurate means of predicting the change in pollutant loadings in response to development. This information is needed by planners and engineers to make rational non-point source pollution decisions at the site level.

The Simple Method Calculation, Table C.1, is intended for use on development sites less than a square mile in area. As with any simple model, the method to some degree sacrifices precision for the sake of simplicity and generality. Even so, the Simple Method is still reliable enough to use as a basis for making non-point pollution management decisions at the site level.

Phosphorus pollutant loading (L, in pounds per year) from a development site can be determined by solving the equation displayed in Table C.1.

Table C.1 Phosphorus Pollutant Export Calculation

$$\text{Pollutant Loading, } L = [(P)(P_j)(R_v)/12] (C) (A) (2.72)$$

Where:

- P = Rainfall depth over the desired time interval (inches)
- P_j = Fraction of rainfall events that produce runoff
- R_v = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff. $R_v = 0.05 + 0.009(I)$
- C = Flow-weighted mean concentration of the pollutant in urban runoff (mg/l)
- A = Area of the development site (acres)
- 12 and 2.72 are unit conversion factors

P, Depth of Rainfall

The value of P represents the number of inches of precipitation that falls during the course of a normal year of rainfall. Long-term weather records around the state of Maryland suggest that the average annual rainfall depth is about 40 inches. This can be used to estimate P or a user can substitute the average annual rainfall depth from the closest National Weather Service long-term weather station or other suitable locations for which a reliable record can be demonstrated (> 10 years).

P_j, Correction Factor

The P_j factor is used to account for the fraction of the annual rainfall that does not produce any measurable runoff. Many of the storms that occur during the year are so minor that all of

the rainfall is stored in surface depressions and eventually evaporates. As a consequence, no runoff is produced. An analysis of regional rainfall/runoff patterns indicates that only 90% of the annual rainfall volume produces any runoff at all. Therefore, P_j should be set at 0.9.

R_v , Runoff coefficient

The R_v is a measure of the site response to rainfall events, and in theory is calculated as:

$R_v = r/p$, where r and p are the volume of storm runoff and storm rainfall, respectively, expressed as inches.

The R_v for the site depends on the nature of the soils, topography, and cover. However, the primary influence on the R_v in urban areas is the amount of imperviousness of the site. Impervious area is defined as those surfaces in the landscape that cannot infiltrate rainfall consisting of building rooftops, pavement, sidewalks, driveways, etc. In the equation $R_v = 0.05 + 0.009(I)$, “ I ” represents the percentage of impervious cover expressed as a whole number. A site that is 75% impervious would use $I = 75$ for the purposes of calculating R_v .

A, Site Area

The total area of the site located in the Critical Area IDA (in acres) can be directly obtained from site plans. If the total area of the site is greater than one square mile (640 acres), the Simple Method is may not be appropriate and applicants should consider utilizing other approaches, such as modeling or monitoring.

C, Pollutant Concentration

Statistical analysis of several urban runoff monitoring datasets has shown that the average storm concentrations for the keystone pollutant phosphorus do not significantly differ between new and existing development sites (see Appendix D for a summary of current data). Therefore, a pollutant concentration, C , of 0.30 mg/l should be used in this equation.

The Simple Method equation listed in Table C.1 can be simplified to the equation shown in Table C.2. Applicants with verified data indicating alternative values may choose to use the original Simple Method equation as represented in Table C.1; otherwise, Table C.2 represents the revised Simple Method equation and associated values.

Table C.2 Simplified Pollutant Loading Calculation	
Pollutant Loading, $L = (R_v)(C)(A)(8.16)$	
Where:	
R_v	= Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff. $R_v = 0.05 + 0.009(I)$
I	= Site imperviousness (i.e., $I = 75$ if site is 75% impervious)
C	= Flow-weighted mean concentration of the pollutant in urban runoff (mg/l). $C = 0.30$ mg/l
A	= Area of the development site (acres)
8.16	= Regional constant and unit conversion factor

PROPER USE OF THE SIMPLE METHOD

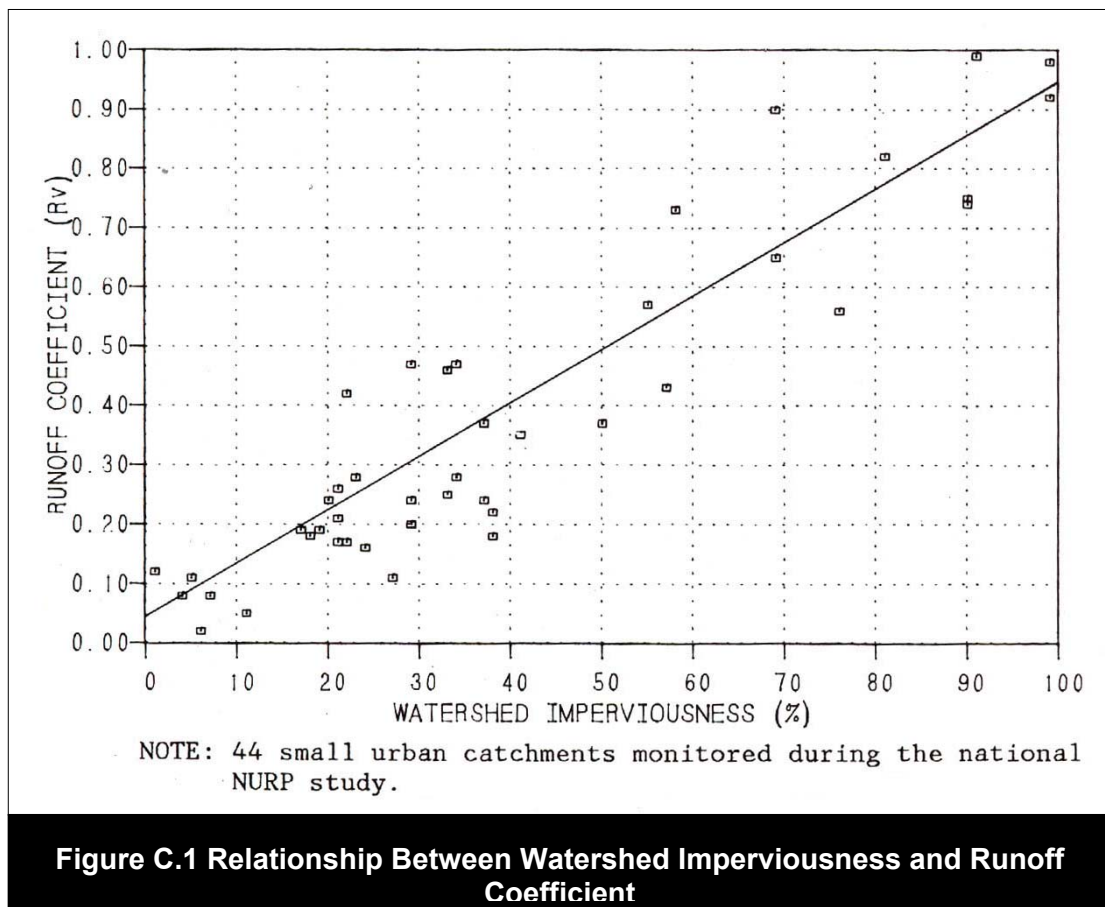
The Simple Method should provide reasonable estimates of changes in pollutant export resulting from development activity. However, several caveats should be kept in mind when using the method, and these are discussed below.

The Simple Method only estimates pollutant loads generated during storms. It does not consider baseflow runoff and associated pollutant loads. Typically, baseflow is negligible or nonexistent at the scale of a small development site, will not change appreciably before or after development or redevelopment, and can be safely neglected. Pollutant levels in baseflow were generally low and seldom can be distinguished from the natural background as based on a 1978 study that evaluated land-use runoff relationships in the Washington, DC metropolitan area (NVPDC, 1978). Consequently, baseflow pollutant loads normally constitute only a small fraction of the total load delivered from a site.

However, if the level of watershed development is quite low (less than 5 % impervious), the Simple Method may not accurately estimate the total annual load, although it should be reasonably good at estimating annual storm loads for the site (which is the focus of the 10% Rule). For example, in large low-density residential watersheds, as little as 25% of the annual runoff volume may occur as stormflow. In this case, the annual baseflow nutrient load may be equivalent to the annual stormflow nutrient load.

The Simple Method provides a general planning estimate of likely storm pollutant export from development sites less than one square mile (640 acres) in size. More sophisticated methods, such as simulation modeling may be needed to analyze large and complex watersheds.

Finally, the Simple Method does not accurately estimate pollutant loadings under certain special conditions. These include site disturbances during actual construction and prior to land stabilization, heavily industrialized areas, heavily traveled highways, and undeveloped areas, such as croplands.



PHOSPHORUS LOADS FROM UNDEVELOPED SITES

Numerous difficulties arise when computing phosphorus loads from undeveloped areas. First, the variability in phosphorus export from undeveloped areas is enormous even for the same kind of land use. Some undeveloped land uses (e.g., cropland) export more phosphorus than even the most intensive new development while others (e.g., forests) generate much less phosphorus than the least intensive new development.

Second, the Simple Method is not a reliable tool for predicting pollutant export from undeveloped land uses. The method was developed for use on urban areas where annual stormwater runoff can be predicted by a runoff coefficient (R_v) that is a simple function of watershed imperviousness. No such relationships exist for undeveloped areas. Factors such as soils, slope, and vegetative cover exert a much stronger and more variable influence on annual storm runoff in these areas. As an example, the agricultural areas can produce 60% more runoff annually than forested areas in the coastal plain (Lomax *et al.*, 1982), despite the fact that both land uses have essentially no impervious cover. The Simple Method is not sensitive enough to account for these important differences between undeveloped land uses.

BENCHMARK LOADS FROM UNDEVELOPED LAND

To avoid unnecessary confusion and to promote a consistent and reliable approach for computing loads from undeveloped land uses, it is recommended that local jurisdictions adopt a single, fixed benchmark load for all undeveloped areas. The benchmark should represent an average load measured for a typical mix of undeveloped land uses (i.e., forests, fields, crops, pastures, meadow, etc.), and is exclusively used as the basis for estimating pollutant removal requirements for new development sites only.

A number of monitoring studies have been conducted on experimental watersheds in the Maryland coastal plain that can be used to derive a representative benchmark phosphorus load. For example, seven small, mixed-use catchments were monitored over a three year interval in the Rhode River watershed on slightly rolling topography of the Western Shore of the Chesapeake Bay in Maryland (Correll *et al.*, 1977a and Correll *et al.*, 1977b). The seven Rhode River watersheds contained a wide diversity of land use, all of which had at least six of the following seven land use types: row crops, hay, upland wetlands, forest, old fields, pasture and rural residential. Moreover, the distribution of land use types within individual watersheds was quite heterogeneous.

Annual storm phosphorus export (lbs/acre) was derived for each of the Rhode River watersheds by subtracting the baseflow component from the total annual load reported by Correll *et al.* (1977b). When computed in this manner, annual storm phosphorus export averaged 0.65 lbs/acre/year over 12 watershed years, and ranged from 0.2 to 1.5 lbs/acre/year.

In addition, two test watersheds were monitored over two years on the flatter terrain of Horn Point on the Eastern Shore of the Chesapeake Bay in Maryland (Lomax *et al.*, 1982). One 212 acre watershed was devoted to agriculture, and was cropped in the common two year corn/soybean/small grain rotation. A smaller 75 acre forested watershed was also monitored. Although accurate estimates of storm export could not be derived from the reported data, it was evident that the storm phosphorus concentrations on both of the Eastern Shore watersheds were considerably lower than those reported for Rhode River. In addition, the authors noted that storm runoff in the two watersheds was also very low, presumably due to the sandy soils and flat topography. Based on the reported data, it is likely that phosphorus export on the flatter Eastern Shore is lower than that of the more rolling Western Shore. Future monitoring data derived from the Wye River experimental watersheds should help to clarify this matter.

Until better data become available, it is recommended that local jurisdictions adopt a fixed benchmark load of 0.5 lbs/acre/year from undeveloped areas. It is felt that this interim value best represents an average phosphorus load that might be expected for undeveloped lands throughout the Critical Area. However, local jurisdictions may wish to adjust the value if better, more localized monitoring data are available.

Some of the consequences of the benchmark load on the pollutant removal requirement computed for new development sites are shown in Figures C.2 and C3. As can be seen, new

development sites that are less than 17% impervious will not be subject to the keystone pollutant removal requirement under the 10% Rule. However, these sites will still be subject to local stormwater management regulations and the State best management practice (BMP) preference list.

It can also be noted that as new development on a previously undeveloped site becomes very intense (60% or more impervious), on-site BMP options are not likely to achieve full compliance with the 10% Rule (unless additional off-site areas drain to and are served by the BMP at the site). Therefore, it is likely that intensive new developments may require the implementation of offsets or the collection of offset fees.

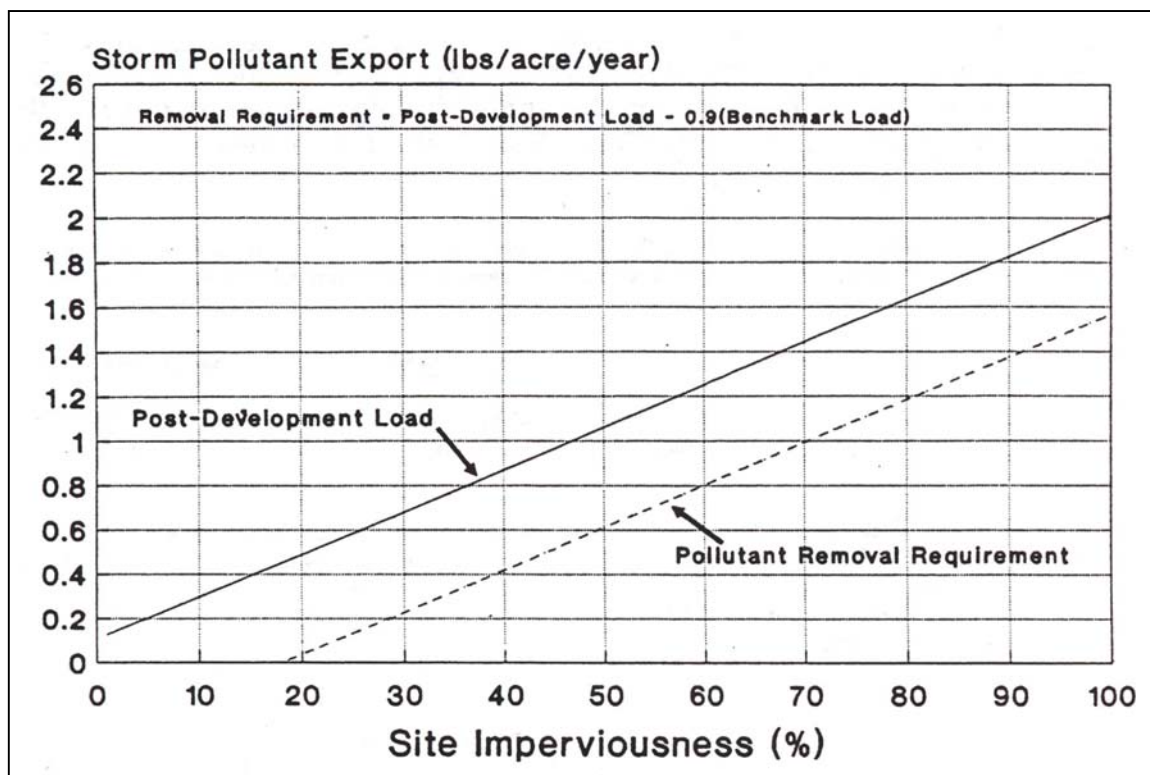


Figure C.2 Pollutant Removal Necessary at New Development Sites as a Function of Imperviousness

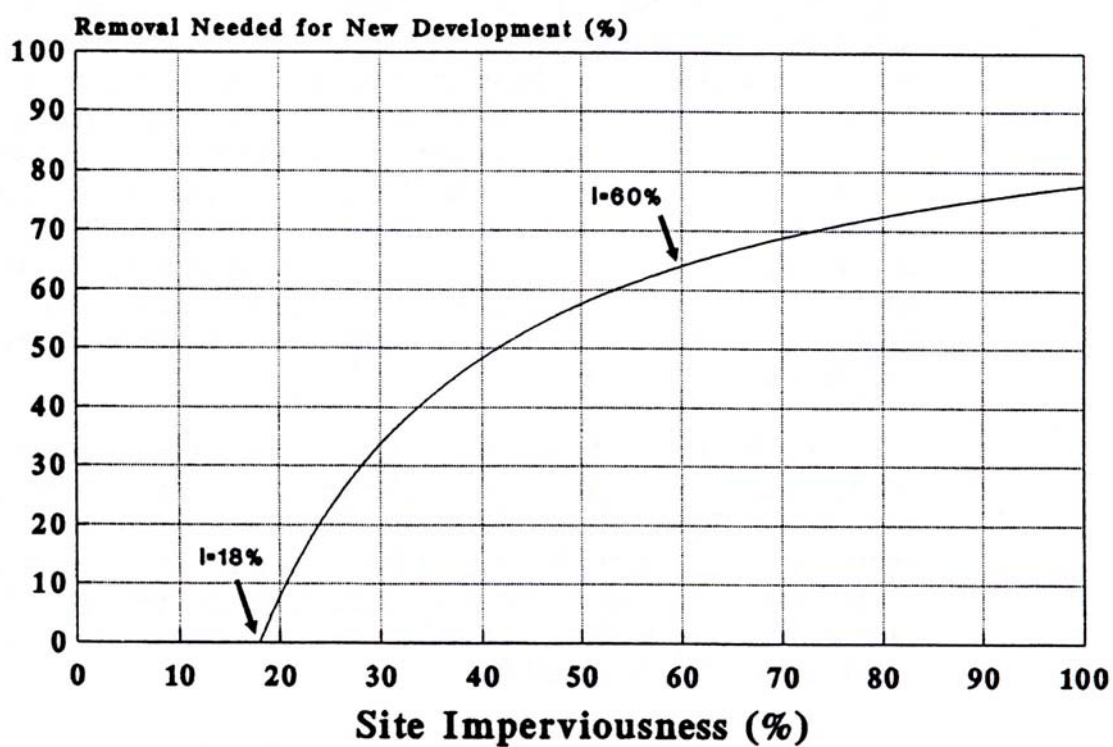


Figure C.3 The Effect of Benchmark Loads on Pollutant Removal Requirements

